



Individual solar and smart energy systems

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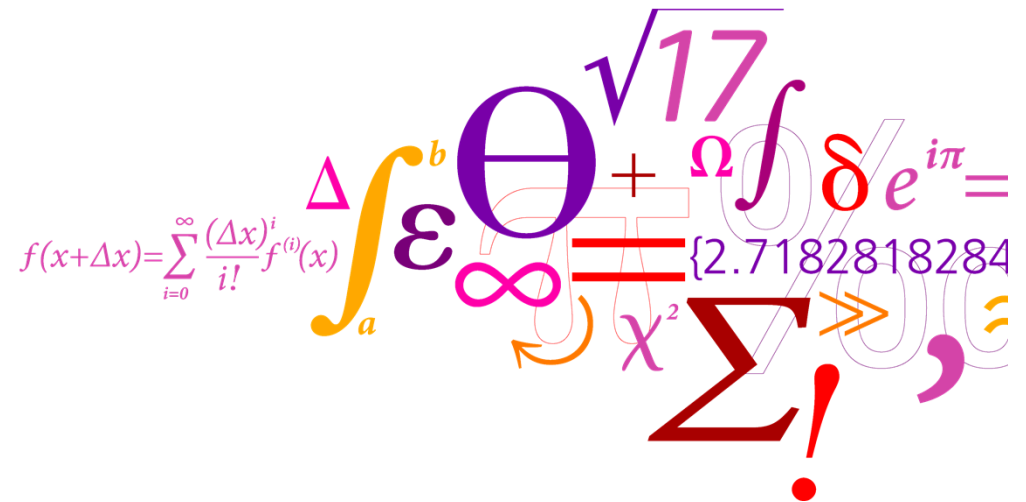
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Individual solar and smart energy systems

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World solar heating market 2000 - 2011

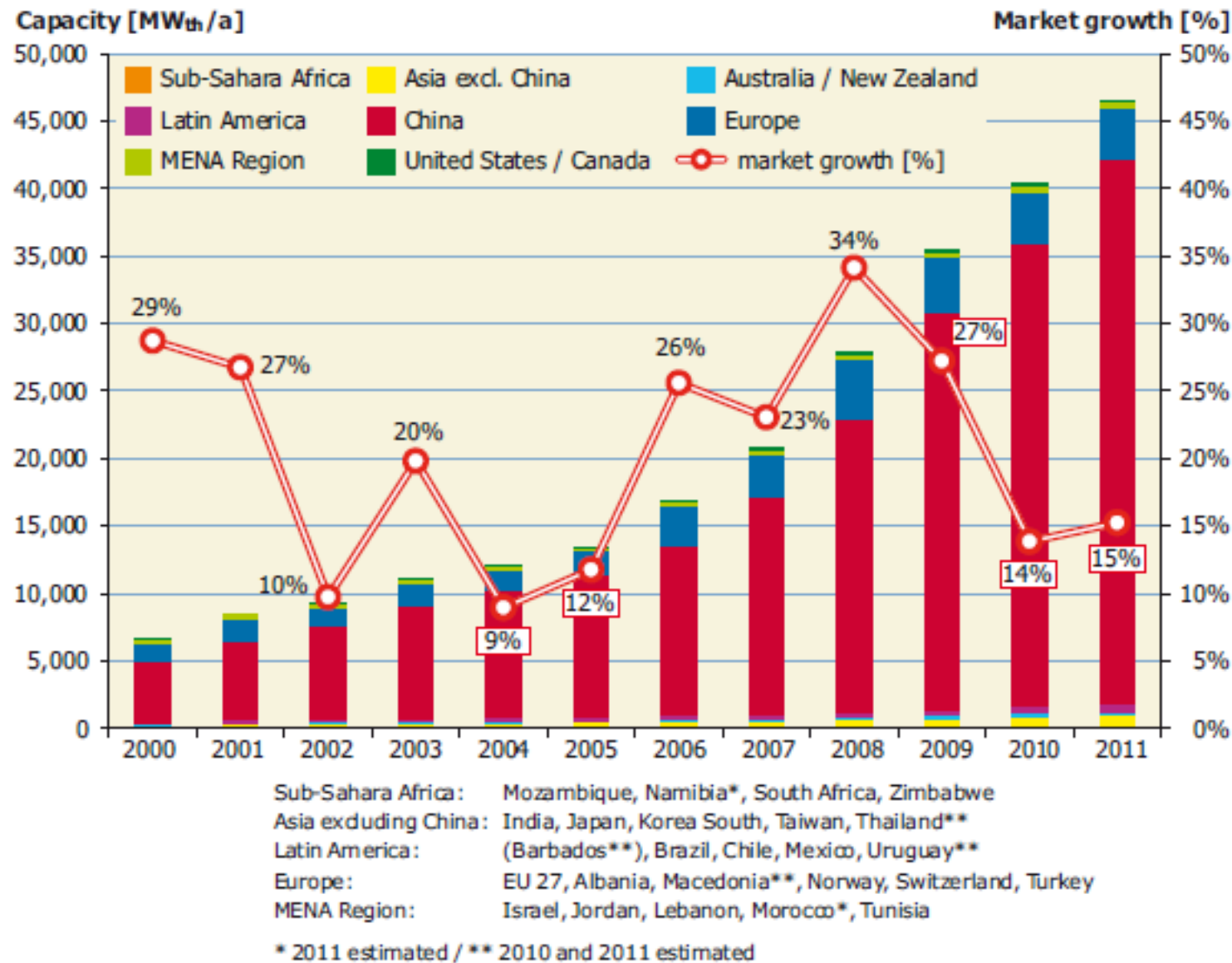


Figure 19: Annual installed capacity of flat plate and evacuated tube collectors from 2000 to 2011

Chinese and European markets 2000 - 2011

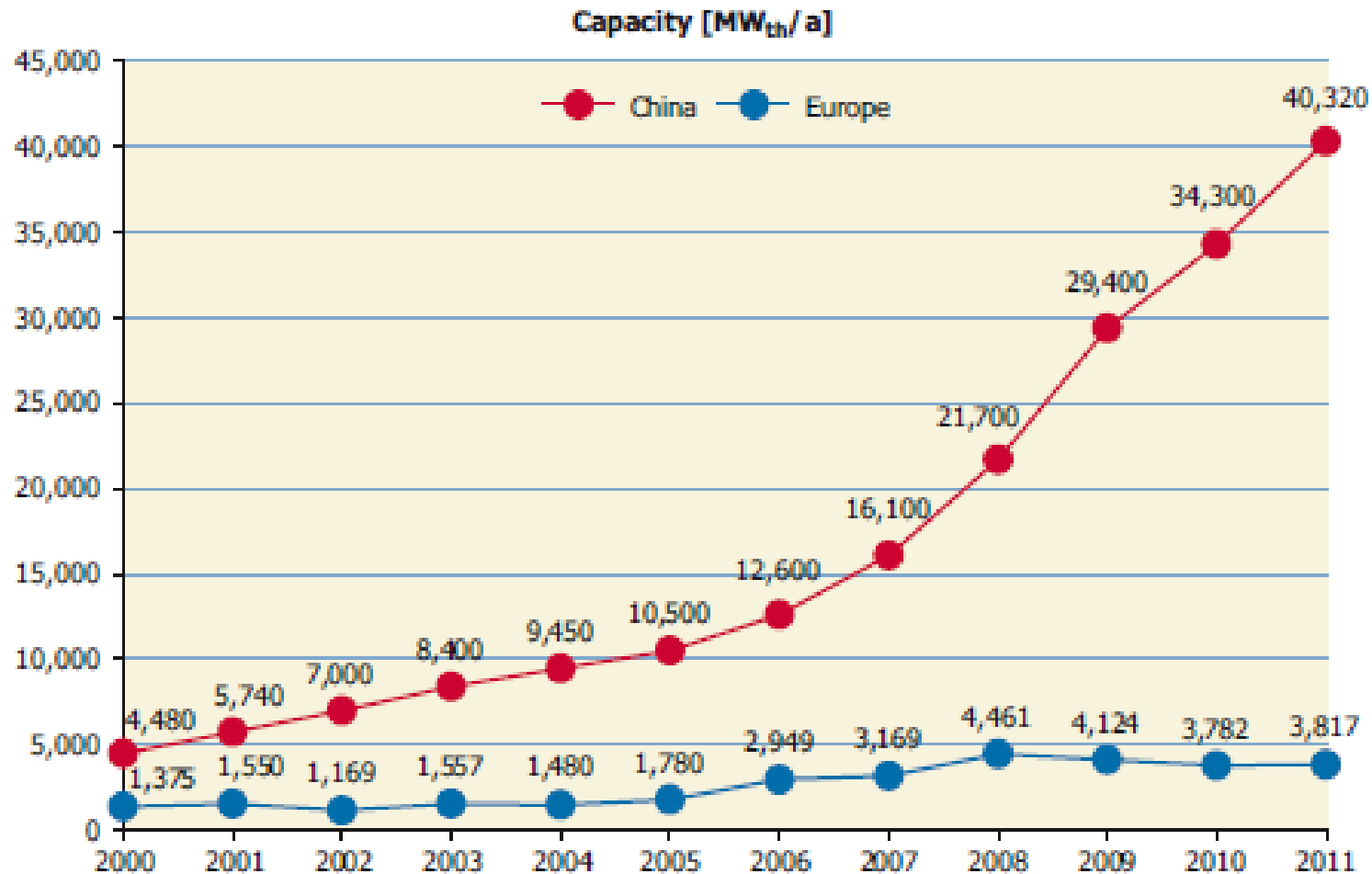


Figure 20: Annual installed capacity of flat plate and evacuated tube collectors from 2000 to 2011 in China and Europe

Installed solar heating power per person, end of 2011

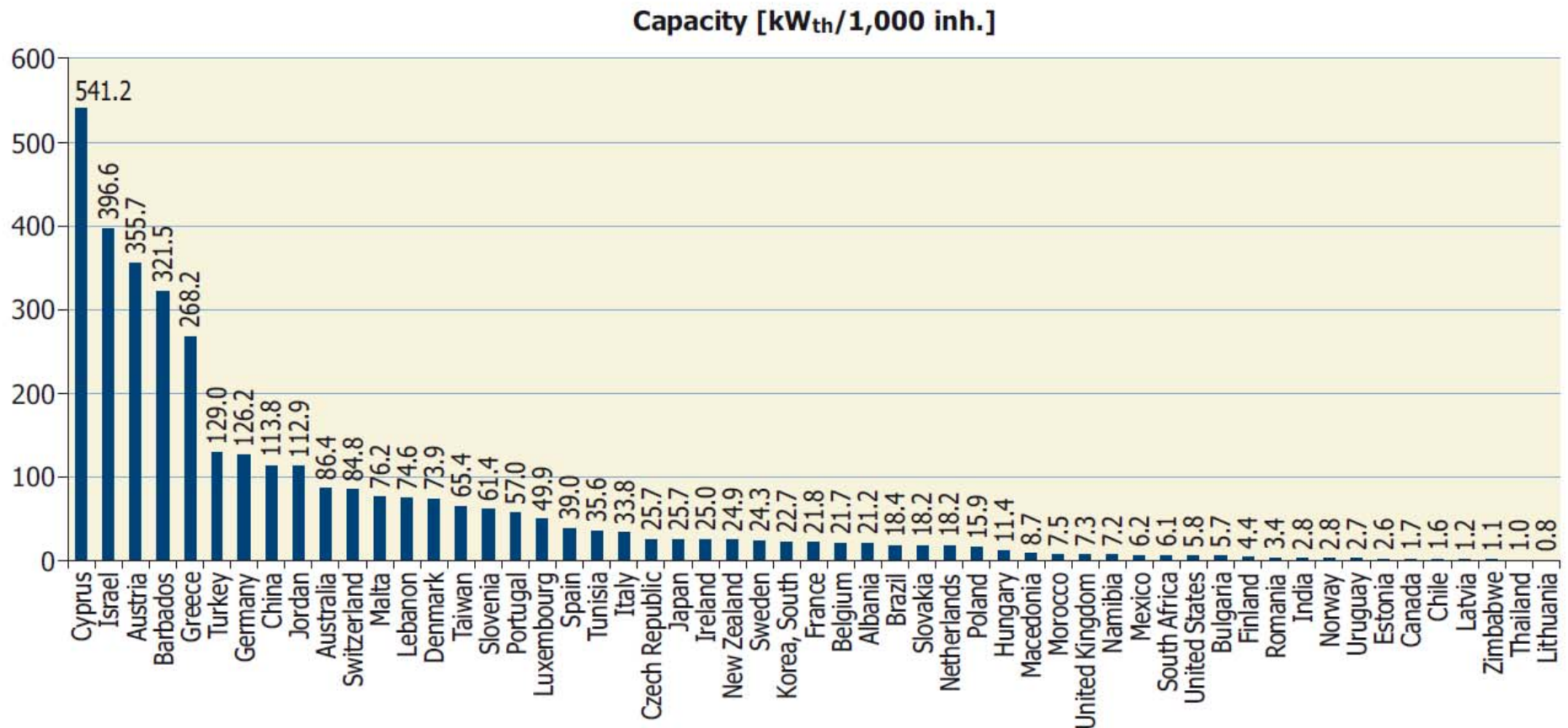


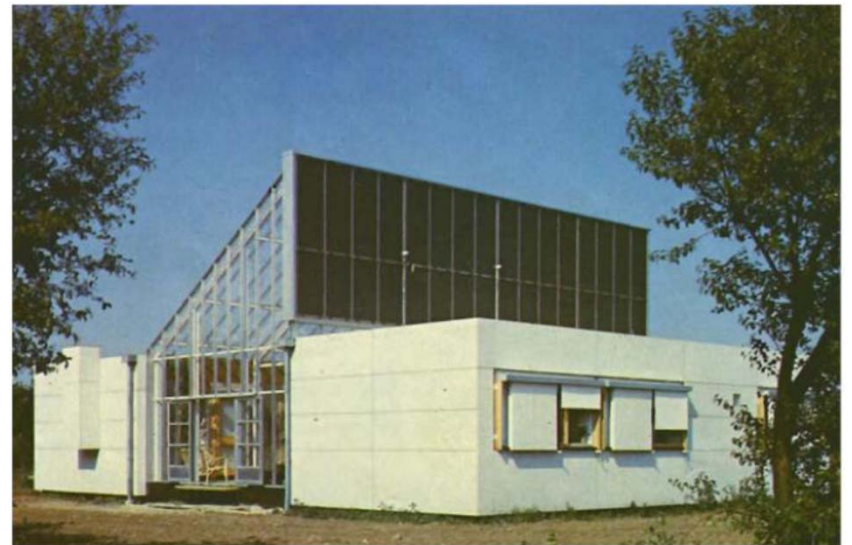
Figure 7: Total capacity of glazed flat plate and evacuated tube collectors in operation in kW_{th} per 1,000 inhabitants by the end of 2011

ESTTP vision for solar heating 2050

50% of Europe's heating and cooling demand covered by solar thermal

New buildings: Heating and cooling demand fully covered by solar thermal

Zero energy house, DTU 1975



Renovation of buildings: More than 50% of heating and cooling demand covered by solar thermal

http://www.estif.org/fileadmin/estif/content/esttp/downloads/SRA/ESTTP_SRA.pdf

Need for education, research, development and demonstration now!

European large scale solar heating plants, end of 2012

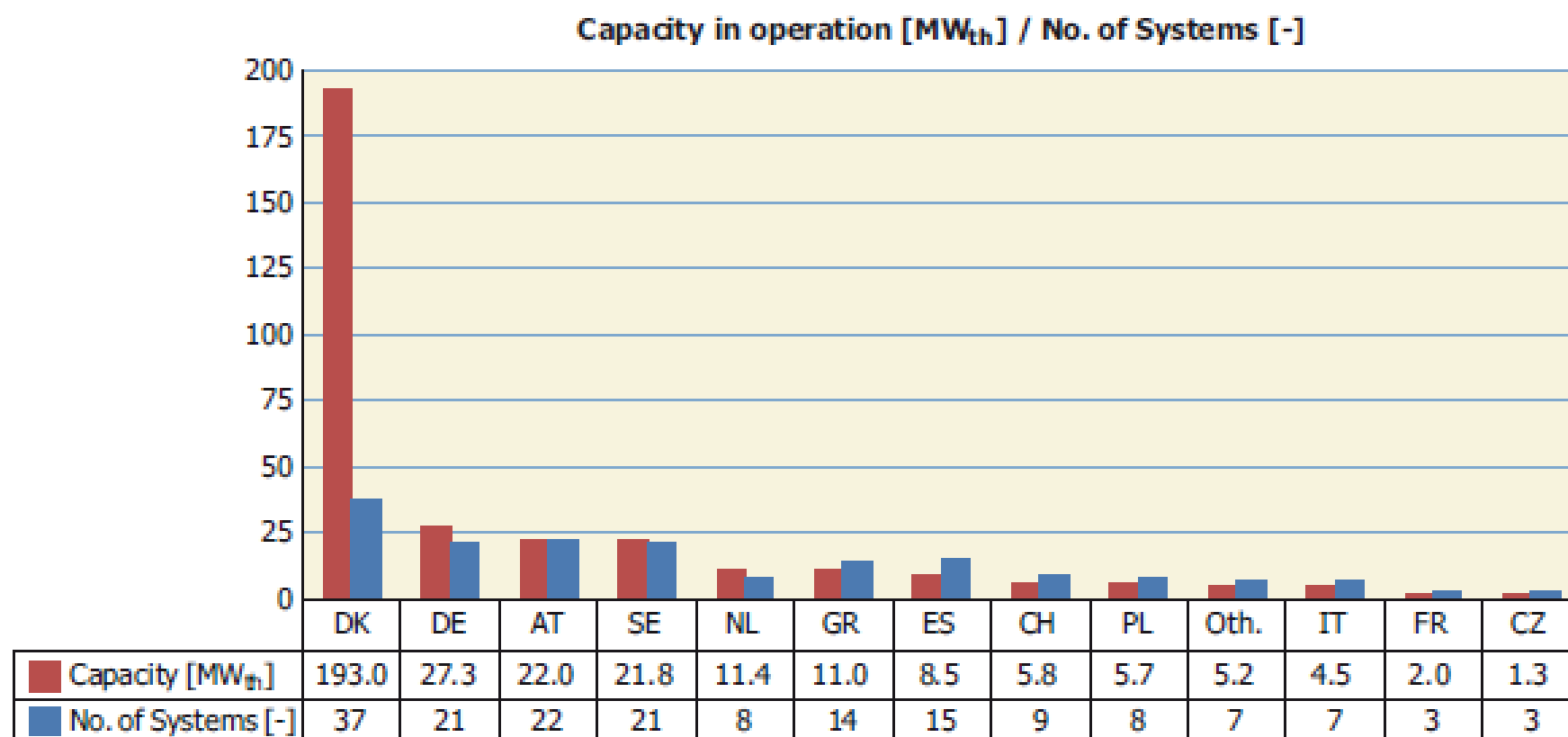
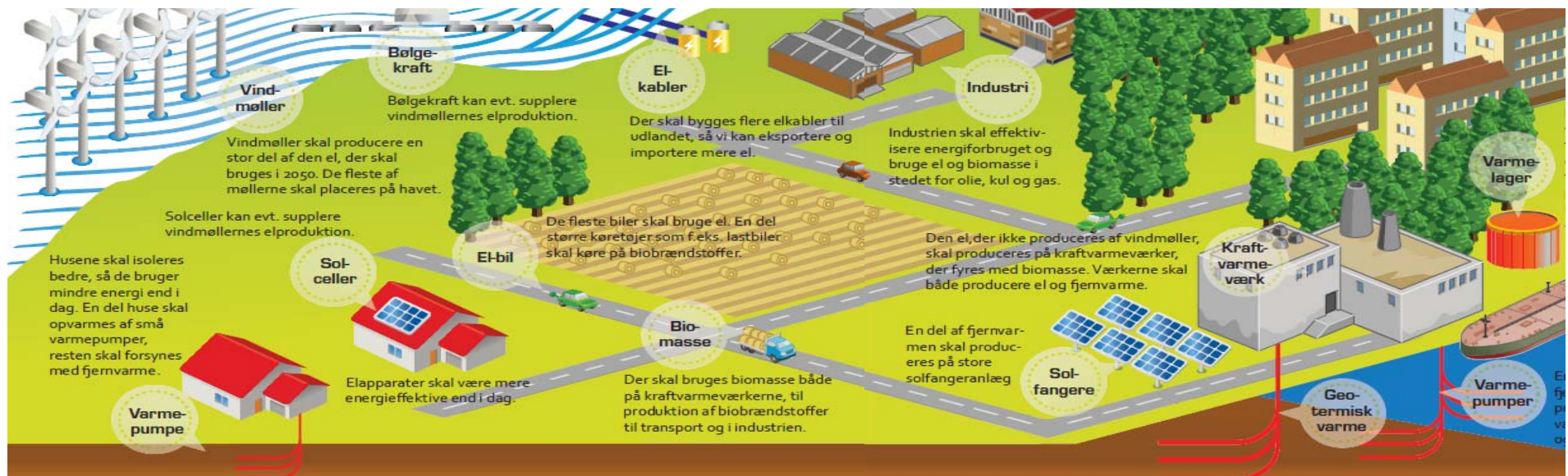


Figure 45: European large-scale solar heating systems by the end of 2012
(Source: Jan-Olof Dalenbäck - Chalmers University of Technology)

Denmark: Phase out all fossil fuels before 2050



Wind energy:

2012: 30% of electricity

2020 → 50 % of increased electricity consumption (incl. transport, heat pumps, ...)

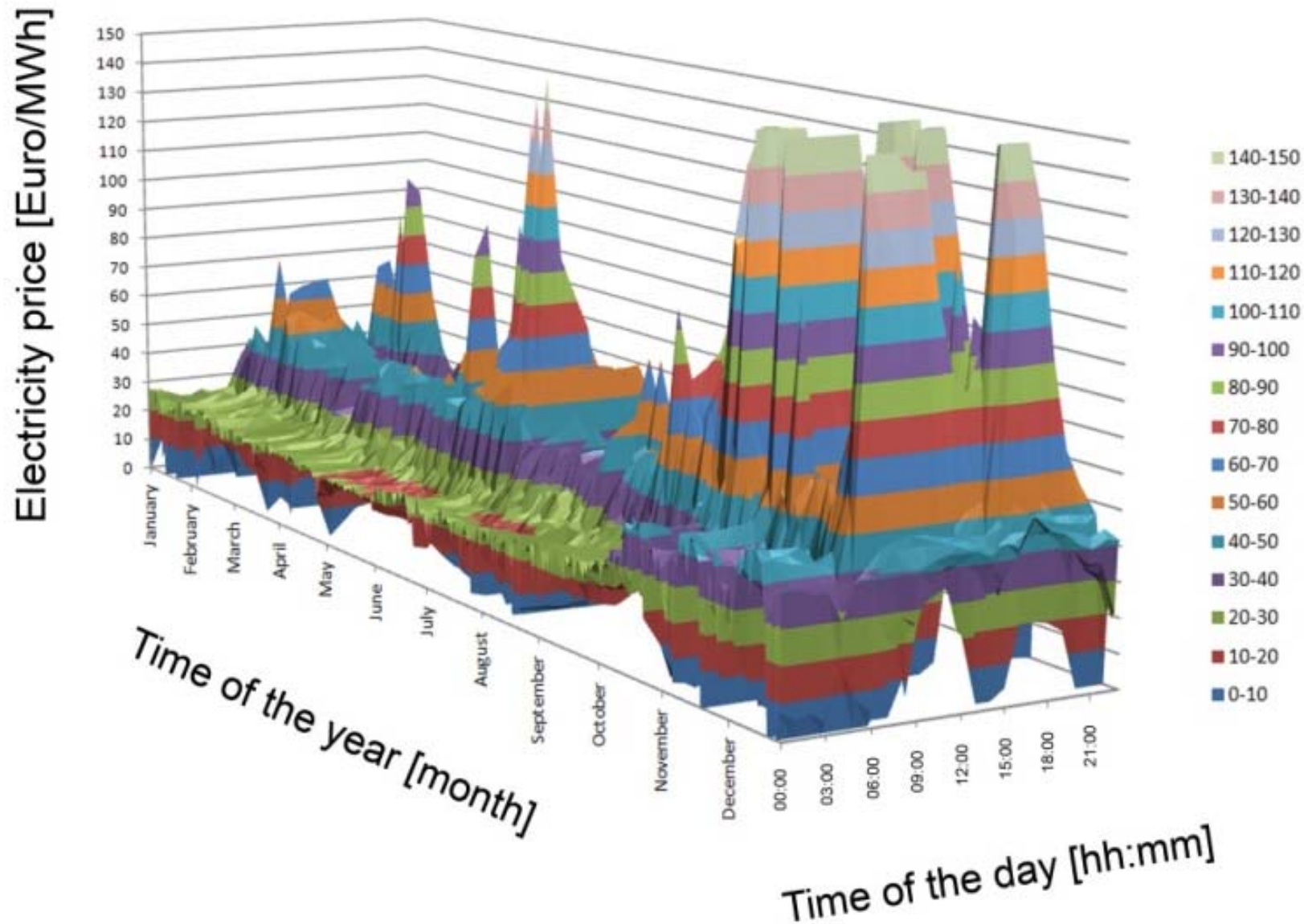
Solar heating:

2030: 15% of decreased heating demand

2050: 40% of decreased heating demand – 80% of this by district heating & **20% individual systems**

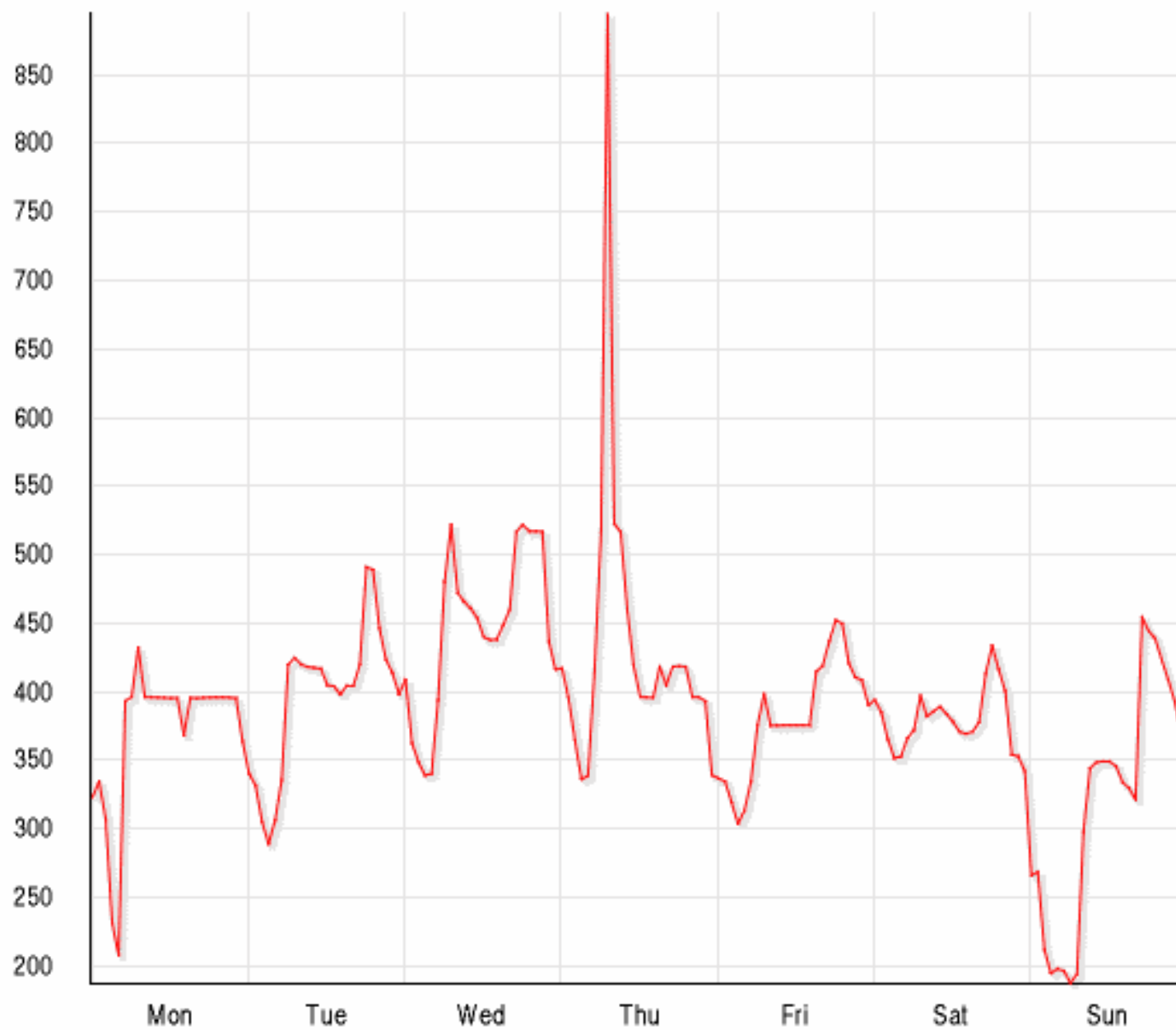
Danmark west, 2007 - from Nordpool

Electricity price variations during one year



Electricity price,
DKK/MWh

Denmark west, November 3.-9., 2008



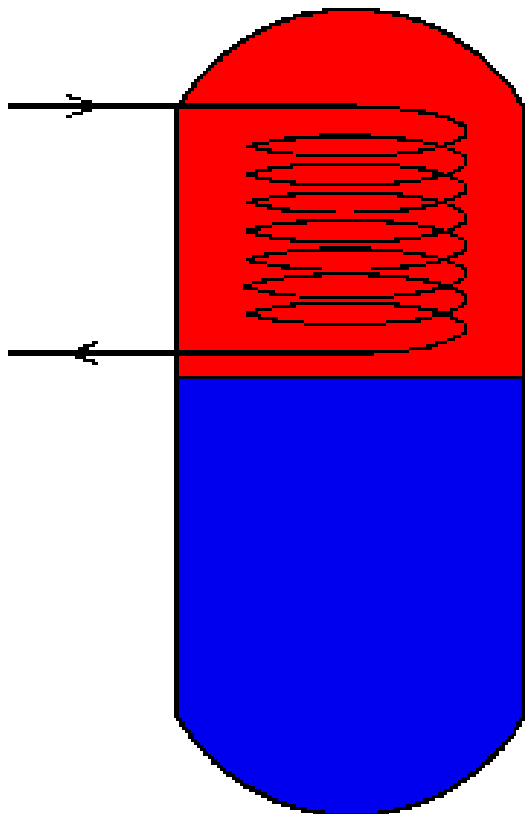
Individual solar/electric heating system for the future smart energy system

Individual solar/electric heating systems with smart heat storages, which can be heated by solar collectors and by electricity in periods with low electricity prices

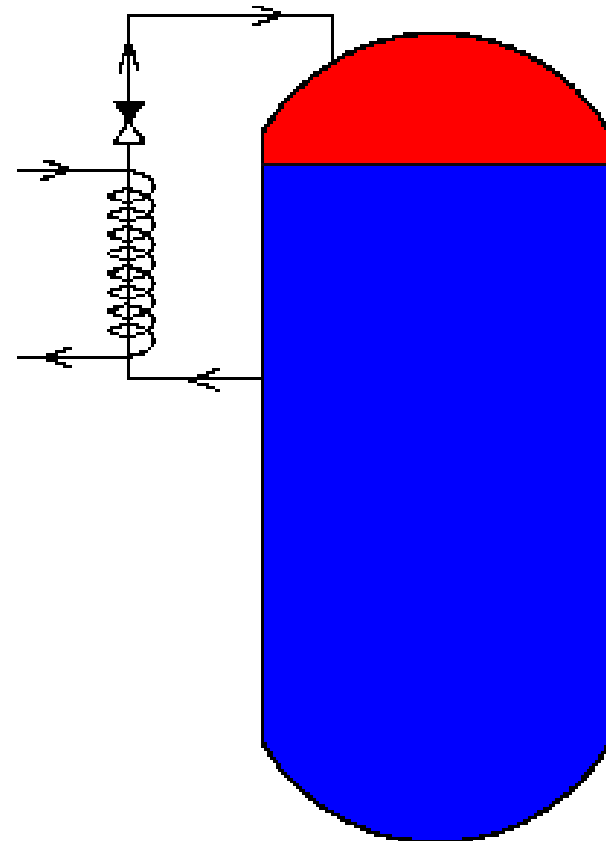
- Heat is produced by solar collectors and by electric heating elements or a heat pump
- Electric heating elements/heat pump if possible only in operation in periods where solar heat can not fully cover heat demand and where the electricity price is low
- System equipped with a smart heat storage (variable auxiliary volume) and a smart control system based on prognoses for:
 - heat demand
 - solar heat production
 - electricity price

Smart solar tanks for solar heating systems

MARKETED SOLAR TANK



SMART SOLAR TANK



TANK HEATED FROM THE TOP

INDIVIDUAL FLEXIBLE TIMER/ENERGY CONTROL SYSTEM

Solar heating systems with smart solar tanks

Increased thermal performance by up to 35% due to:

- ☺ Decreased tank heat loss
- ☺ Increased solar heat production

Further, also additional improved cost efficiency due to:

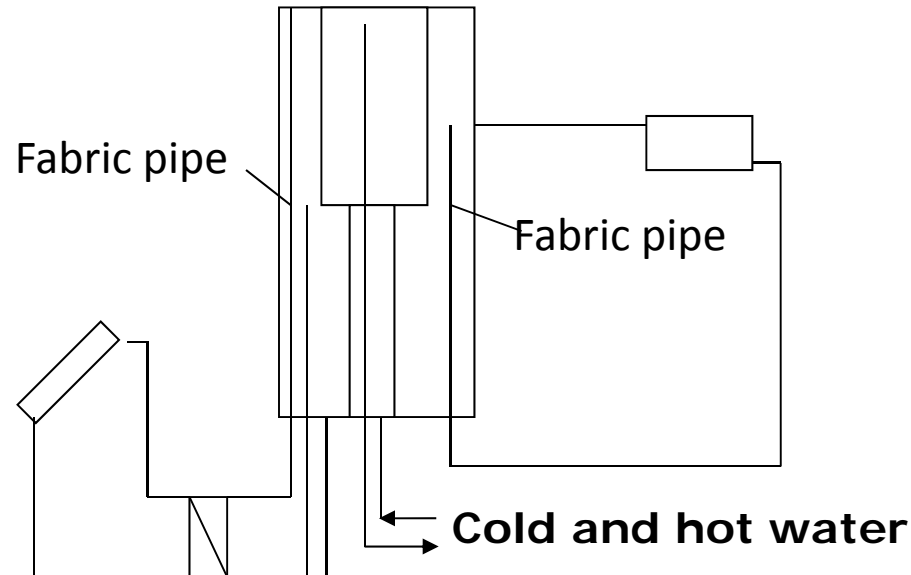
- ☺ Use of low electricity price

Three systems tested side by side

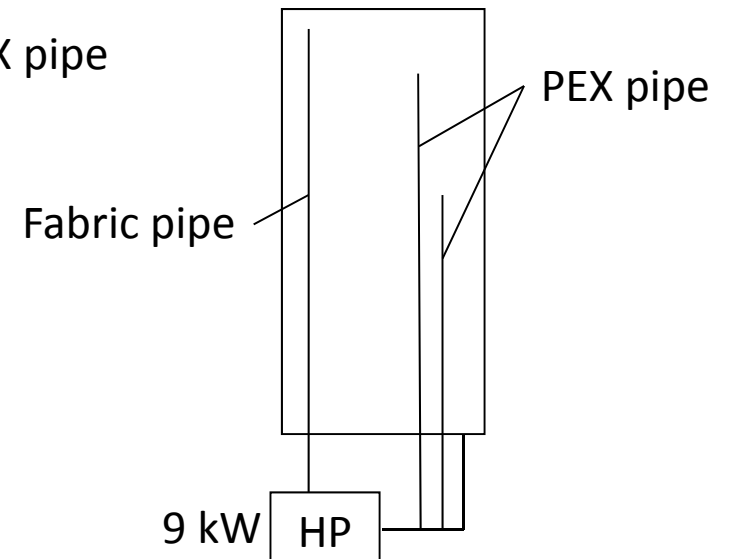
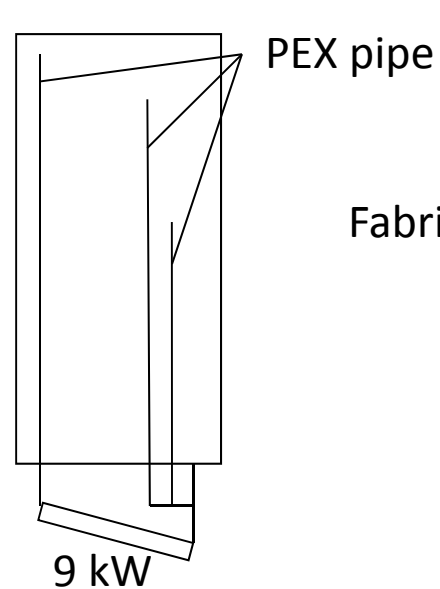
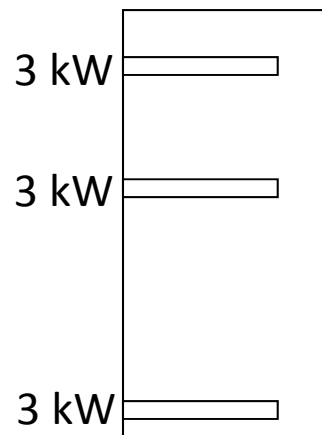


- 9 m² solar collector
- 735 l smart solar tank. Auxiliary: One electric heating element, three electric heating elements, heat pump
- Smart control system - heat content in tank, weather forecast, coming heat demand, coming solar heat production, coming electricity prices from NORDPOOLSPOT

Solar collector loop & discharge loops



Auxiliary heating principles



Measured results for spring 2013



- Heat price for two systems based on one electric heating element and three electric heating elements almost the same
- Heat price for systems with electric heating element(s) = 2 x Heat price for system with heat pump

Information available in report "Solar/electric heating systems for the future energy system", Department of Civil Engineering, Technical University of Denmark, report R-288. Can be downloaded from:

http://www.byg.dtu.dk/~media/Institutter/Byg/publikationer/byg_rapporter/byg-r288.ashx

Theoretical calculations - results

Home owner

- Heat price for house: 100%
- Heat price for house with 10 m² solar combi system: 70-80%
- Heat price for house with 10 m² smart solar heating system with electric heating elements and variable electricity price: 30-50%
- Heat price for house with 10 m² smart solar heating system with heat pump and variable electricity price: 15-25%

Society

- Socio-economic benefit of smart solar heating systems compared with a reference scenario with oil and gas boilers: The total benefit: 2200 - 6100 DKK per system per year

Conclusions

- Individual smart solar heating systems with electric heating elements/heat pump and variable electricity price are more cost-effective than traditional solar heating systems
- Individual smart solar heating systems with electric heating elements/heat pump can help integrating wind power in the energy system and contribute to an increased share of renewable energy
- For houses with low heat demand a smart solar heating system with electric heating elements is most attractive
- For houses with normal or high heat demand a smart solar heating system with a heat pump is most attractive

Recommendations



Development of individual solar heating systems for the future

General:

- **Low flow systems:** Serial connected solar collectors of different types, small all in one solutions for solar collector loops including hot and cold pipes, small low energy circulation pumps with variable flow rates
- **Heat stores:** Low heat losses from pipe connections and thermal bridges, good thermal stratification (tank design, inlet stratifiers), discharge from different levels, smart tanks with variable auxiliary volumes, new insulation materials
- **Good interplay** between solar collectors and auxiliary energy supply system
- **Smart control systems**
- **Prefabricated** easy to install **solar tank/energy** system units
- **Drain back systems** using water as solar collector fluid
- **Compact seasonal heat storage:** PCM heat storage, chemical heat stores

Specific:

- Heating systems based on solar collectors, a smart tank with electric heating element(s) and a smart controller for houses with low heat demand
- Heating systems based on solar collectors, a heat pump, a smart tank and a smart controller for houses with normal or high heat demand

Perspectives

- Individual smart solar/electric heating systems for buildings outside district heating systems can in the future play an important role for home owners and for the energy system
- Individual smart solar/electric heating systems combines in an excellent way solar and wind energy